Earth System Research Laboratory
Physical Sciences Laboratory Review
March 9-12, 2010

Response to Review Recommendations and Implementation Plan

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Introduction

The Earth System Research Laboratory (ESRL) appreciates the positive findings and values the recommendations of the Review Panel from the Physical Sciences Laboratory Review conducted March 9-12, 2010.

The ESRL staff worked diligently to provide information about the broad range of physical sciences work being done within the Physical Sciences Division (PSD) and the Global Systems Division (GSD). We were aware that this laboratory review would be an intense event due to the breadth of our work. We are pleased that the dedication and enthusiasm of ESRL leadership and staff in contributing to NOAA's science mission was readily evident to the review panel throughout the event. Comments by the review panel such as "elements of both PSD and GSD should be considered national treasures" with our "top scientists being amongst the world elite," make us especially proud.

The remainder of this document addresses specific recommendations provided from the review panel to ESRL. We have engaged ESRL staff at all levels to address those recommendations. The section numbers that are provided follow the research theme numbers of the review and also correspond to the section numbers of the review panel report. A table at the end of this document provides the summary and schedule of ESRL actions that will be taken to achieve recommendations given by the review panel.

ESRL Response

2.1 General

Verbatim Review Panel Recommendation:
GSD's heavy reliance on external funding should be reduced to alleviate the risk that it may not be capable of achieving its NOAA mission. This will be especially important in the ongoing process of establishing a robust relationship with NCEP.

Response:
During the review, perhaps we did not emphasize strongly how GSD leverages the work in engages beyond NOAA to advance NOAA's mission. For example, information systems work with the Bureau of Meteorology in Australia and the Central Weather Bureau of Taiwan resulted in very significant dividends for development of the Advanced Weather Interactive Processing System (AWIPS), the Graphical Forecast Editor (GFE), and the Local Analysis and Prediction System (LAPS). This work was conducted and delivered under signed Interagency Agreements that added new capabilities to these systems. This type of leveraging gives mutual benefit to both GSD external customers and NOAA, and also applies to other research and development work within GSD in areas such as observing systems, information systems, weather and warning modeling, and data assimilation.

Nonetheless, GSD's significant reliance on external funding is an area that we will address with OAR management to determine the feasibility and method of obtaining a better balance between base and external funding. This would serve to alleviate risks in supporting the NOAA mission and allow us to hire junior staff who will be brought up through the ranks and take up the reins as seasoned staff members depart.

Actions and due dates:
By December 15, 2010, discuss the feasibility and methods of obtaining a better balance between base and external funding with OAR management.

2.3 The Workforce

Verbatim Review Panel Recommendations:

1. ESRL mentors and sponsors should ensure that CI and postdoctoral scientists are not tasked with too many projects.
2. ESRL management should ensure there is at least a modest level of mentoring of junior staff and nurturing of career pathways; ensure that the workforce encompassing CI scientists can be refreshed as needed; review the value of the annual appraisal and promotion processes.
3. ESRL should recognize the challenge of being part of a large work force in a modern federal office building – web-based information about general procedures and resources (seminar announcements, availability of extra-curricular resources such as the gym, and so on) would help with communications that are especially important for the junior workforce. Having the post-docs arrange seminars, providing opportunities for post-docs to meet together, and creating natural gathering areas throughout the building would also help.

4. ESRL should start planning now for replacement of senior management, with a strong mentoring program for potential replacements.

Responses:

1. ESRL mentors and sponsors will be required to review Cooperative Institute (CI) and postdoctoral assignments for each individual to determine what tasking or tasking priority adjustments are needed. Tasking will be reflected in an annual work plan for each individual.

2. Mentoring of junior staff and nurturing their career pathways can help to ensure the success of individuals and all of the organizations involved. ESRL will work toward implementation of Individual Development Plans (IDPs) or equivalent mechanisms depending on the type of junior employee. We will coordinate with each CI and contract firm to encourage appropriate support of this endeavor through their organizations.

   As for replacing CI scientists, the CIs have readily and ably provided new or replacement personnel upon request and specification of duties and requirements. Since the CI workforce refresh need has not heretofore been a problem, no specific action will be implemented at this time.

   The annual appraisal and promotion processes are dependent on the type of employee. For government personnel, the appraisal process is defined by the Commerce Alternative Personnel System, a pay for performance mechanism that is separate from the older personnel system used in other parts of the federal government. The value of this system is greater flexibility to reward government employees with pay increases on a performance basis. Furthermore, federal employees can be considered for promotions above their current maximum level through a Performance Management and Awards Committee (PMAC) that meets up to three times per year and operates with straightforward guidelines to consider promotion submissions from supervisors. For CI and contractor staff, ESRL mentors and sponsors submit annual or more frequent performance input to their respective management for consideration of monetary awards and promotions. The annual appraisal and promotion processes will be reviewed by ESRL, CI, and contractor management to ensure that the goal of rewarding and retaining high quality personnel of all types is being met.

3. Seminar announcements and numerous other communications are already broadcast laboratory-wide multiple times via email. They are also posted throughout the laboratory on bulletin boards and published in weekly intranet publications. Senior staff, mentors, technical leads, and projects leads will be reminded to promote and encourage postdoctoral and graduate student staff participation in the numerous seminars offered.

   The weekly intranet publications include how-to articles, reference links, photos of events, announcements, and a feedback mechanism for the staff. Division-specific intranets provide a wide array of resources, information, and procedures. Wikis are available to personnel also via Division-specific intranets for content collaboration on items and topics of choice, and group-specific Wikis such as for Systems Administrators

are used. These information and collaboration resources will be emphasized to all ESRL staff.

To promote increased readership of intranet publications, we will: 1) Reorganize intranet publications by highlighting new or changed material, and 2) Move older articles to archive pages, establishing a single homepage with links to the archived articles.

We will coordinate with postdoctoral and graduate student staff to set up regular seminars that are open building wide to all postdoctoral and graduate student staff. These seminars will be held in a casual, open, and inviting setting. We will coordinate with the postdoctoral staff to determine the acceptable frequency of holding these seminars. To help our postdoctoral staff and students at all levels to get to know each other, we will work through the ESRL Student Coordinator to provide more organized social events.

Regarding natural gathering areas throughout the building, we will highlight what we have through various means and approach the NOAA Boulder Directors Council to determine the feasibility of any enhancements to existing gathering areas.

4. ESRL managers will be directed to talk with their personnel to determine the aspirations of individuals and the individual training needs to accomplish those aspirations. We expect that some personnel will be interested in maintaining scientific and technical tracks while others will be interested in pursuing management options. ESRL managers will be reminded to offer opportunities to individuals on their staff to take on additional responsibilities and to grant permission for individuals to represent their Division or ESRL at meetings, workshops, and seminars. Local mentoring and on-the-job training opportunities will also be implemented as a method of bringing junior employees up through the ranks. Furthermore, managers will be reminded to encourage the use of existing development programs, mentoring programs, and developmental/rotational assignments that are available in OAR, NOAA, DOC, and other agencies.

Actions and due dates:

1. Review postdoctoral staff assignments for each individual as appropriate to their employment status and make any appropriate tasking adjustments by November 9, 2010. In particular the CIRES staff supervision is by CIRES University employees and guided by the annual CIRES Workplan which is developed in collaboration with NOAA: It is the responsibility of the CIRES supervisor (by law, a University employee) to make appropriate task assignments. This item, as it applies to CIRES will be elevated to CIRES management by 1 January 2011. Most of our postdoctoral scientists come from and are funded by three external competitive programs that are based on a proposed research program and competitive review: these individuals have a great deal of independence and are not subject to tasking by ESRL.
2. Implement mentoring through IDPs or equivalent mechanisms depending on employee type for junior staff (those who began their appointment within the last two years at ESRL) by February 8, 2011, including attention to well-defined performance measures and appropriate performance awards. Review annual appraisal and promotion processes for all federal employees with ESRL managers. Raise the issue with CI, and contractor

management to ensure that the goals of rewarding and retaining high quality personnel are being met by February 8, 2011.

3. The available intranet resources will be emphasized to all employees by October 8, 2010. New hire checklists will be updated by October 8, 2010 to remind managers to inform new personnel of the intranet resources. Intranet publications will be revised to promote increased readership by February 8, 2011. ESRL management will coordinate with postdoctoral and graduate student staff to determine the frequency of holding informal seminars by October 5, 2010. ESRL management will work with the ESRL Student Coordinator by October 5, 2010 to facilitate social events for postdoctoral and graduate student staff. ESRL management will highlight the availability of gathering areas throughout the building by October 5, 2010 and approach the NOAA Boulder Directors Council by December 7, 2010 to determine the feasibility of enhancements to gathering areas within the building.
4. By October 8, 2010, ESRL will document the current level of use of developmental and rotational assignments and, in areas of deficiency, managers will be directed to take an active role in determining the aspirations of their personnel, make use of IDPs as appropriate, provide for training, mentoring, and development opportunities, and to promote use of existing development programs and rotational assignments.

3.1 Climate, Weather and Water Science

Verbatim Review Panel Recommendations:

1. PSD should attempt to get out in front with respect to climate model diagnostics. Like most groups, they are analyzing the last generation of climate models at a time when the next generation of climate models have already been advanced and frozen for AR5. It would be helpful to short-circuit this feedback loop so as to not skip a generation of model development.
2. ESRL should establish a mini-Arctic program (a cross-division theme) to encourage dialogue and collaboration. The potential synergies between Arctic research efforts and model development/validation efforts should be exploited.
3. ESRL should position itself to become a leading hub for Arctic atmospheric research. NOAA should take a leadership role in facilitating some broader international coordination for Arctic observations. With the highlight given to the Arctic in the upcoming NOAA Strategic Plan, the time seems right for ESRL to exert itself in the Arctic. Perhaps the upcoming "Arctic Watch" will be one vehicle for broadening ESRL's visibility in the Arctic. Partnerships with CPC and GFDL on Arctic variability and predictability research would make NOAA more prominent in broader programs such as SEARCH (Study of Environmental Arctic Change).
4. ESRL management should have a plan for the sustenance of the scientific leadership of this group while planning how to identify, nurture, and groom the future leaders. The lack of Federal positions and the use of CI staff who have little hope of moving to Federal positions appears to provide challenges to sustaining ongoing excellence in science and science leadership.

Responses:

1. This recommendation raises an important issue of proactive vs. reactive diagnostic analyses, which is relevant not just within PSD but across multiple organizations and

agencies. "To get out in front with respect to climate model diagnostics", especially with respect to an arbitrary Intergovernmental Panel on Climate Change (IPCC) clock, is easier said than done. Accomplishing and sustaining such an ambitious role for PSD will require: 1) Having not just NOAA, but multi-agency (and perhaps even international) support at the highest levels to perform proactive model diagnoses of the IPCC models as they are being developed, and 2) Having PSD play a more important role in the IPCC deliberations and assessments. Certainly, PSD staff members are both willing and able to perform these functions, but they will need formal recognition from NOAA headquarters to do so. One possibility is to advance model diagnostics capabilities within PSD, perhaps as a part of any proposals for a new NOAA Climate Projection Prototype, with crosscutting links to the other components of ESRL and GFDL.

2. PSD understands the importance and visibility of its polar research efforts and the potential for broader collaboration across ESRL. PSD has considered elevating Arctic activities to the status of a full Branch within PSD versus a research team within the Weather and Climate Physics Branch, and strengthening collaborations across ESRL. The FY11 President's Budget proposed an increase in support for Arctic activities that would support growth of PSD's Arctic program, but its future will depend on Congressional action. ESRL has defined several cross-division integrating themes. Although the Arctic is clearly relevant to many of these themes, it is not a theme unto itself as it perhaps should be. Given the imminent formation of a NOAA Climate Service, the exact configuration for a cross-division Arctic or polar program within ESRL is unclear.
3. This should be addressed in the immediate future by initiating a series of Arctic theme related discussion groups in ESRL. An example of themes would be black carbon, surface fluxes and atmospheric transports. The groups should have an *a priori* mandate to identify actionable items and execute them. This should be tasked to the ESRL Management and Leadership Team (MLT). If ESRL should not exist after a NOAA reorganization, PSD (or PSL as it were) would provide the groundwork for this in a revised Strategic Plan. Ms. Uttal is also in discussion with the National Science Foundation (NSF) to have the International Arctic System for Observing the Atmosphere (IASOA) be officially adopted as an NSF funded program office. There is a possibility the director for this would be a CIRES appointment that would work within ESRL.
4. The issue of maintaining science expertise and scientific leadership is broadly relevant across ESRL. The climate observing group (Arctic, Air-sea, and future renewable energy) situation is a bit different because a significant amount of the national expertise is concentrated in PSD and there is a well-known trend of declining University strategic education in meteorological hardware. While PSD has had a healthy **influx** of talented postdoctoral personnel in the last decade, that has been balanced by an **outflux** of those individuals to attractive University faculty positions. If we look at scientists in the group with strong observing system credentials who are under age 50, there are a few CI people and no Federal employees. On the plus side, we have good connections with graduate students at the University of Colorado (CIRES and INSTAAR), although there are some very time consuming bureaucratic barriers. Right now, we don't have a decent concept of the best strategy. Developing talent from the grassroots student level may be reaching too deep. We believe this problem is solvable, but only in an ESRL (or maybe even a NOAA-wide) context. To some extent this maps onto the issue of "the NOAA and

national context for sustaining climate observing competency…" In the short-term, we recommend creating a small task force to address the issue.

Actions and due dates:

1. By 03/31/2011 - (1) PSD will explore organization changes following decisions on a NOAA Climate Service. Should a Service should be created, PSD will look how to best organize to provide the appropriate bridging between our science enterprise and the needs of the Service. (2) The IPCC Fifth Assessment Report (AR5) process has begun already and both Drs Perlwitz and Pulwarty of PSD are engaged as lead and convening lead authors respectively. PSD will continue to identify research avenues using AR5 model results to advance the science necessary for the IPCC and National assessments.
2. Within 90 days of the formation of a NOAA Climate Service, PSD→PSL (Physical Sciences Laboratory) will discuss possible configurations for an enhanced and better-integrated Arctic program with NCS management. If the NCS is not created, the ESRL Director's Office will initiate the development of a Polar Theme within 90 days of a final decision.
3. Within 90 days of the formation of a NOAA Climate Service, PSD→PSL will discuss possible avenues for elevating NOAA's leadership role in facilitating some broader international coordination for Arctic observations with NCS management
4. By 03/31/2010 - PSD will: (1) create a demographic profile of the personnel within the climate and the climate-weather interface observation groups, (2) develop projections of near-term and longer-term transitions, (3) develop a list of personnel options (e.g., holding on to talented postdoctoral personnel, converting a few of our gifted CI people to federal, or recruiting new Feds from University/Research Laboratories), and (4) develop and implement a long-term plan to transition key positions using the options identified above.

3.2 Modeling, Data Assimilation and Advanced Computing

Verbatim Review Panel Recommendations:

1. ESRL needs to set realistic expectations and understand the operational constraints of an operational NWP system, including computer efficiency of models.
2. ESRL's short- and long-term planning and technological transfer processes for NWP systems need to be improved and implemented in close collaboration with the National Centers for Environmental Prediction (NCEP). ESRL, NCEP, and stakeholders need to establish the requirements, roadmaps, and detailed implementation plan (e.g. including schedule, critical path, etc.) for NOAA's chain of innovation for NWP (research, development, operation, and service).
3. GSD should continue to monitor the skills of FIM forecasts. Care must be given to ensure FIM is using the same operational data stream (including QA/QC) to minimize any difference in the operational environments between ESRL and NCEP and to break down barriers to transition.
4. The status of key projects (e.g. RUC, Rapid Refresh, etc.) should be monitored and documented regularly by a formal technological transfer management and scientific committee that would review and document the performance of the existing and developing NWP systems, using agreed operational validation and verification methods and metrics with standard WMO recommended practices and metrics.

5. GSD should develop 5-year strategic and implementation plans, firmly embedded within a NOAA plan for environmental modeling and prediction, for its vision of a global coupled atmosphere-and-ocean-chemistry model. Such a plan should leverage off and contribute to and coordinate with existing efforts within NOAA, including GFDL.
6. In developing the EnKF, FIM and NIM, ESRL should establish stronger collaborations not only with other NOAA labs and operational entities but also with labs in other agencies. The use of the ESMF is absolutely critical to enhance these collaborations. It is recommended that ESRL commit to ESMF fully – not only at the superstructure level but also at the infrastructure level. The NOAA Global Interoperability Program has provided funding and direction and should be taken very seriously.

Responses:

1. For close to 20 years, GSD has worked with the Environmental Modeling Center (EMC) and other organizations and agencies relying on GSD for their weather forecast applications to ensure that proposed changes in analysis and forecast systems [e.g., Rapid Update Cycle (RUC), Rapid Refresh (RR), Flow-following Finite-volume Icosahedral Model (FIM), Local Analysis and Prediction System (LAPS), and Space-Time Multiscale Analysis System (STMAS)] are consistent with available resources, and we agree completely with this point. The granularity recently designed in the FIM model is an example of GSD's readiness to adjust to available computational resources. GSD has also worked with EMC, NCEP Central Operations (NCO), and consultant staff hired by NCEP to optimize models on NCEP computers. Yet another example of this is currently underway where GSD software engineers are working with NCEP and NCEP consultants to introduce OpenMP and other optimizations into the FIM model. ESRL already understands that the initial FIM implementation at NCEP will be as a member of the Global Ensemble Forecast System (GEFS). The resources available have not yet been specified, but we expect the needed resolution to be between 50-80km and ESRL is prepared to tailor FIM resolution to available computational resources. ESRL also recently initiated, with NCEP engineers and consultants, a successful effort to greatly improve efficiency for the Weather Research and Forecasting-Advanced Research Weather Research and Forecasting Model (WRF-ARW) version on the NCEP Central Computer System (CCS) for the upcoming Rapid Refresh implementation, now planned for early 2011.

2. There seems to be confusion about how GSD makes decisions regarding model development priorities. Support for model development comes from NOAA (through both base funds and other NOAA support) and the Federal Aviation Administration (FAA). GSD leads development of a 7-year Model Development and Enhancement (MD&E) Plan with several other modeling groups each year as required by the FAA Aviation Weather Research Program. Thus, GSD plans are fully vetted with NCEP, the National Center for Atmospheric Research (NCAR), and the FAA before moving ahead. Since NCEP is also represented on the MD&E team, considerable coordination exists in planning and setting priorities. GSD also partakes in the annual NCEP review as a key participant, and there are many briefings given to the National Weather Service Office of Science and Technology (NWS/OST) and other parts of NWS including NCEP's Storm Prediction Center and the Aviation Weather Center. We regret that these extensive

interactions with other parts of NOAA in planning, coordination, and execution were not made more apparent to the review panel.

With contributions that are closely coordinated with NCEP and other parts of NWS, GSD plays a direct role in the orderly transition of various Numerical Weather Prediction (NWP) methods to the operational community. GSD has entered into Memorandums of Agreement (MOAs) with NCEP on model developments. GSD has also developed charters with detailed NCEP adoption and implementation plans for previous Rapid Update Cycle (RUC) changes, and is now revising one regularly regarding the Rapid Refresh (RR). The RR MOA includes a plan to merge the RR and North American Meso (NAM) model toward a North American Rapid Refresh Ensemble (NARRE) by 2013. NCEP/EMC and GSD also plan to use the NARRE to provide initial conditions for an ensemble version of the 3-km hourly High-Resolution Rapid Refresh (HRRR). ESRL has greatly increased its use of community code – WRF, Gridpoint Statistical Interpolation (GSI), unipost – for RR and HRRR, and this is also indicative of close collaboration with NCEP and the larger Numerical Weather and Environmental Prediction (NWEP) community. We also note GSD's increasing role in the Developmental Testbed Center (DTC). The DTC is supported through interagency collaboration and was established to improve research to operations and operations to research processes.

3. The skill of FIM, including different FIM versions versus each other and the Global Forecast System (GFS), is calculated daily and revised at least monthly by the FIM development group. These scores are calculated via an interactive verification application available under http://ruc.noaa.gov/stats. The software for calculation of anomaly correlation coefficients in this application was provided by NCEP, and follows World Meteorological Organization (WMO) standards. GSD uses the operational GFS initial conditions in its primary real-time FIM run at 30-km horizontal grid spacing. The Ensemble Kalman Filter (EnKF) model uses the global prepbufr files, plus satellite data from NCEP, just as the Global Data Assimilation System does. Thanks to the use of the ESRL-developed Scalable Modeling System (SMS, a directive library for MPI parallelization), initial ports to NCEP computers for RUC and FIM have been quite routine. While transfers of NCEP models (e.g., GFS and NAM) have been problematic to non-IBM environments, transfers of ESRL-developed models into the NCEP IBM environment have been quick and without major problems. Note that the ESRL FIM testing environment is not fully "operational", although it is a real-time testbed environment. ESRL will establish monthly reports published on the web to provide the skill from different versions of FIM versus GFS. ESRL will continue to collaborate with NCEP on the implementation of FIM on NCEP's CCS, including application of NCEP verification software.

4. A formal process is followed at NCEP for all model changes, requiring approval by EMC and NCEP Central Operations (NCO) Directors, and ultimately, the NCEP Director as well. This process includes collaborative development of model change charters to identify requirements, testing processes, and points and dates of different stages of

approval. This procedure is quite rigorous and is followed by ESRL for all changes to the RUC and Rapid Refresh.

The NWS (via Regions and individual forecast offices), the NCEP National Centers [especially the Storm Prediction Center (SPC) and the Aviation Weather Center (AWC)], and other interested user groups serve as a *de facto* review committee advising the NCEP Director on the quality of new methods proposed for implementation. ESRL also responds to requirements articulated from NWS.

GSD participates in many model monitoring and model development management activities at NCEP. One of them is participating with a presentation on the RUC and RR at the annual NCEP Production Suite Review. GSD has developed very powerful development verification capabilities, including online verification against radiosondes and surface observations for RUC, RR, FIM, NAM, and GFS. The GSD verification capabilities contribute strongly to improvements in Tropical Cyclone (TC) verification, including TC false alarm and demographic measures. GSD is developing an effective radar reflectivity and precipitation verification capability for 3-km scale HRRR and other model forecasts. For further information, please see:

- NCEP verification web page for RUC, GFS, NAM – http://www.emc.ncep.noaa.gov/mmb/mmbpll/mmbverif
- Verification web page for RUC, RR (multiple versions), NAM, GFS, and, FIM vs. raobs, GPS (under http://gpsmet.noaa.gov), surface obs

- In addition, to improve monitoring and documenting, all significant transition projects will be tracked in the OAR Project Database and include key project status information such as milestones, deliverables, timelines, and referenced transition agreements.

5. Development of a GSD Strategic Plan is in progress, beginning with a two-day workshop held in Estes Park, Colorado during early July, followed by development of a 10-year strategic plan proposal by each GSD Branch Chief in mid-August. The first draft of the GSD Strategic Plan will be complete by early October 2010. This plan will be reviewed by the ESRL Director, ESRL Division Directors, OAR management, NWS/OST, NWS Office of Climate, Water and Weather Services (OCWWS) leadership, and NCEP [in particular, EMC, SPC, AWC, the Hydrometeorological Prediction Center (HPC), and the Climate Prediction Center (CPC)].

   ESRL has been involved with National Unified Operational Prediction Capability (NUOPC) planning over the past two years and GSD will continue its current roles in NUOPC and the Earth System Prediction Capability (ESPC). ESRL took a leading role with the first ESPC meeting held September 7-9, 2010 that involved planning toward a common ESPC within the U.S.

   GSD has led the vision within NOAA for inline chemistry in atmospheric models for weather forecast time scales and for meso-spatial scales, as well as development of WRF-

Chemistry, a multi-laboratory effort. WRF-Chemistry, in turn, has already been adapted to global application within the FIM, and is a candidate for the chemistry component of the NOAA Environmental Modeling System [NEMS, the Earth System Modeling Framework (ESMF) version at NCEP]. GSD's demonstrations of inline chemistry in WRF-Chemistry (for Texas Air Quality Study, HRRR-western U.S. and Alaska, and others) and now in FIM-Chemistry with real-time fire/smoke and volcanic ash forecasts are helping to create and accelerate a vision in NOAA, especially in OAR and NWS. Other drivers for inline chemistry or coupled model development include:

- Renewable energy (RE) – solar and winds (via Planetary Boundary Layer)
- Aviation (visibility, clouds)
- Microphysics – aerosol interactions
- Improved general forecasts (e.g., 2-m temperature, surface winds, etc.)
- Arctic application
- Great Lakes application

GSD will initiate a coordination meeting on inline chemistry modeling and data assimilation with NWS and OAR colleagues within six months and seek funding to support FIM-Chemistry work with colleagues through collaborations with ESRL Divisions and others outside of NOAA.

Other opportunities for improving chemistry forecasting using satellite data assimilation can directly improve aerosol initial conditions within the forecast models. In turn, better aerosol initial conditions can result in improved radiance assimilation within forecast models.

Regarding strategic and implementation plans embedded within a NOAA plan for environmental modeling, the NOAA Environmental Modeling Enterprise (EME) governance is currently in development. When the NOAA environmental modeling plan is developed and implemented, GSD will adhere to the requirements specified to develop and enhance capabilities in support of NOAA environmental modeling strategies and priorities.

6. ESRL is working closely with NCEP, the NASA Global Modeling and Assimilation Office, the U.S. Navy, and others toward multiple advanced modeling and data assimilation capabilities. We have incorporated the evolving NEMS architecture, based on ESMF, into ESRL model development for the FIM, and will do likewise for a 2012-13 version of the Rapid Refresh. ESRL collaborates on ESMF development with NCEP and has committed significant resources toward NEMS over the last several years. We have personnel on staff dedicated to the NOAA Global Interoperability Program and we have begun working with the new NOAA Environmental Software Infrastructure and Interoperability (NESII) group. Within the next six months, we will explore working even more with the NESII group.

Actions and due dates:

1. None.
2. None.

3. Establish monthly reports published on the web to provide the skill from different versions of FIM versus GFS by October 5, 2010.
4. Report significant transitions projects in the OAR Project Database by January 30, 2011.
5. Produce the first draft of the GSD 5-10 year strategic plan by October 5, 2010. Initiate a coordination meeting on inline chemistry modeling and data assimilation with NWS and OAR colleagues by February 8, 2011, and seek collaborative funding.
6. Explore working more with the NESII group by February 8, 2011.

3.3 Climate, Weather and Water Services

Verbatim Review Panel Recommendations:

1. ESRL should look to define additional metrics (beyond publication count) on the transitions of products to operational services.
2. ESRL should have a stronger connection to CPC in its planning of climate service products. The unknown in this recommendation is the role of CPC in the NCS. Surprisingly, CPC, which has been a co-leader within NOAA (with CDC and then PSD) in developing climate products, is currently not planned to be part of the NCS.
3. There should be clearer roadmap plans for testbed activities, including transition to operations and/or maintenance of observational capabilities that have been identified as essential for particular applications.

Responses:

1. The CIRES Climate Diagnostics Center, and later the ESRL PSD Climate Analysis Branch, has been using two milestones that were developed to track the transition of research into operational services. The first metric "New experimental climate products and services developed" tracks the prototyping of new potential information streams that could support decision making. The second metric "Experimental research products introduced in operational setting" tracks the success in having operations adopt experimental climate products and services. Other ESRL metrics relevant in the tracking of transitions of products to operational services include "% skill score improvement in experimental U.S. Seasonal forecasts" and "Increase skill of medium range forecasts of tropical precipitation". Because the NCS planning teams are looking at performance metrics, PSD will monitor this activity so as to align it activities and metrics appropriately.

2. PSD works closely with Climate Prediction Center (CPC) on climate reanalysis, monitoring, attribution, and predictions. ESRL/PSD and CPC work together on strategic plans within the framework of the NOAA Climate Goal. While ESRL/PSD looks to CPC as the operational conduit for climate monitoring and prediction research findings, whether CPC will be in the NOAA Climate Service (NCS) is being debated, and will be decided, at a much higher level within NOAA Headquarters. Nevertheless, PSD and CPC are, and will continue, working together to develop mechanisms to ensure the development and delivery of monitoring and prediction services across temporal and spatial scales that will be transparent to users.

3. The Hydrometeorology Testbed (HMT) Implementation Plan (2009) provides a roadmap for activities in the major activity areas of Quantitative Precipitation Forecasting (QPF),

Quantitative Precipitation Estimation (QPE), Snow Information, Hydrology, and Decision Support Tools. The executive summary is available online at http://hmt.noaa.gov. The full plan can be requested from the HMT Project Manager.

Actions and due dates:

1. Dr. Webb has had responsibility for leading the development of the NCS Strategic Vision and Framework document, part of which deals with metrics for success. PSD will continue to be engaged in this process as the NCS generates more global metrics that will apply to this new Service. ESRL will contribute, as appropriate,to reporting transitions to applications for NOAA's Government Performance and Results Act (GPRA) new demonstration performance measure related to transitions during FY11.
2. Within 90 days of the formation of a NOAA Climate Services that will also result in a final determination of CPC either within or outside of the NCS line office, PSD → PSL will work with NCS management to develop either internal agreements or cross line office MOAs to establish mechanisms to ensure that the development and delivery of monitoring and prediction services across temporal and spatial scales that will be transparent to users.
3. None

3.4 Technology Transfer and Outreach Activities

Verbatim Review Recommendations:

1. ESRL management should engage in discussion with the NWS AWIPS-II program. Collaboration with the NASA SPoRT center and IMAPP could help transition new technology to the NWS forecast offices.
2. GSD should work with NOAA and other US and or international science oriented organizations, such as NASA, DARPA, or NSF to develop indices suitable for measuring the effectiveness and efficiency of technology transfer.
3. ESRL should obtain and review FAA's REDAC report on barriers to research transition into operations for lessons learned.
4. Technology transfer roadmaps that track investment in science to ultimate value in use should be developed.
5. ESRL should consider working with the private sector to rethink the ways forecast information might be created and disseminated in the new broadband connected world.
6. A multi-year strategy for targeting outreach activities should be developed. The resources and outcomes achieved in this area should be assessed.
7. For major education and outreach efforts like virtual worlds and SOS, a formal evaluation process that includes educational value should be developed and implemented.

Responses:

1. GSD's role in AWIPS-II is different from its earlier role in AWIPS-I when GSD had the role of developing AWIPS-I. AWIPS-II development was outsourced to industry by NWS beginning in 2005. In AWIPS-I, Boulder, Colorado and Norman, Oklahoma Weather Forecast Offices (WFO) had testbeds running with real-time forecaster operational interaction. That is not the case at this point in the AWIPS-II development program. Rapid Prototyping was the method employed in the development of AWIPS-I, with quick feedback from WFO forecasters and thorough coordination with other

government agencies throughout the development process. This is lacking in AWIPS-II. We propose the following actions if approved by NWS. We will use Rapid Prototyping for the AWIPS-II extended tasks assigned to GSD. For example, the Integrated Hazards Information Services (IHIS) project will begin forecaster prototype feedback in September 2010. While this does not directly address AWIPS-II proper, the extended projects will significantly enhance AWIPS-II capabilities once AWIPS-II is fielded. GSD will write a proposal to NWS for integrating more operational forecaster interaction and feedback into the AWIPS-II extended task development process, through a testbed environment or research and development proving ground shared by GSD and the NWS Boulder WFO. Included in this proposal will be travel funding to bring WFO forecasters from around the nation to Boulder for extended task feedback during the research and development stage. This is vitally needed for tight integration among the various government entities involved in AWIPS-II.

ESRL scientists contribute to NASA Short-term Prediction Research and Transition Center (SPoRT) through participation on the Science Advisory Committee (Dr. Marty Ralph in PSD; 2007- present and Dr. John McGinley in GSD; 2003-2006). However, there is currently no direct ESRL role with SPoRT to transition new technology to NWS WFOs. SPoRT actively collaborates with 11 Weather Forecast Offices as well as the Spaceflight Meteorology Group from the Southern Region. Through ESRL's efforts in enhancing communication and collaboration across the NOAA testbeds, we have actively engaged with SPoRT to share information about our overlapping/coinciding research. For more information regarding NOAA's collaborations with SPoRT see: http://weather.msfc.nasa.gov/sport/. We currently have no direct collaboration with the NASA International MODIS/AIRS Processing Package (IMAPP) for transitioning new technology to NWS offices. We will investigate any opportunities to collaborate with IMAPP.

2. ESRL would welcome the implementation of such a formal process and believes it would be beneficial. Developing more suitable indices for measuring the effectiveness and efficiency of technology transfer can be done, but this is not trivial. Significant resources would have to be allocated to this task. Project funding has not been sufficient to cover the additional resources that would be required to establish and evaluate suitable indices for measuring the effectiveness and efficiency of technology transfer. Processes and indices would be different for each project since various stakeholders have different transition to operations protocols. For example, NWP projects do not rely on the NWS Operations and Services Improvement Process (OSIP) to determine the readiness of technology transfer. By February 8, 2011, we will establish a matrix of generalized, quality, performance, and maintainability metrics. This matrix will be populated with information obtained from performance measurement systems of various collaborators within NOAA and other organizations such as NASA, DARPA, NSF, and FAA.
The notion of measuring the efficiency and effectiveness of technology transfer has merit. However, as an alternative, resources may be better utilized by making the technology transfer process more efficient and effective. For the most part it seems to be *ad hoc*, differing from case to case. The approach for AWIPS-I used rapid prototyping followed by evaluations, and then refinements and adjustments were made to the system

based on user feedback. The results proved very positive. Taking this type of approach might be a better investment.

3. We will obtain and review the FAA REDAC report to determine elements from this report with potential to improve transition of ESRL research to operations. This review will be completed by February 8, 2011.

4. GSD has been involved with other members of the scientific and development community in building a number of Science and Technology Roadmaps that include: Aviation Weather, Fire Weather, Hydrometeorology, Ensemble and Probabilistic Forecasting, and Numerical Modeling. Economic measures have been documented by customers such as the Forest Service in fire weather applications and by the FAA for aviation weather analysis. ESRL research efforts are focused in areas that provide economic and societal benefit. By February 8, 2011, we will organize a Task Team to explore the feasibility of engaging an economist or other experts (out-sourced) to assist with developing cost-benefit analyses of technologies transferred.

5. GSD is currently developing new web-based technologies to disseminate integrated hazard information. GSD also partnered with social scientists in the academic community to explore new ways of communicating forecast uncertainty for improved decision-making. Private sector partners are engaged as advisors for input and feedback. The 4D Data Cube/Weather Information Database (WIDB) is another technology to utilize broadband that empowers private industry to develop new value-added products. By November 15, 2010, we will examine the multiple ways currently used by industry to include mobile technology to disseminate forecasts in the new connected world in partnership with other stakeholders. This will include handheld technology. To develop new ways of creating and disseminating forecasts, we will explore scalability and access of technology provided by industry and being used or proposed for use by NWS and other national and international organizations.

6. GSD is actively engaged in a leadership role in the development of multi-year plans related to K-12 educational outreach activities directly linked with cutting-edge NOAA research in the area of satellite validation and numerical modeling of land surface and biosphere processes. Science On a Sphere® (SOS) is a conduit for educating all sectors on major issues facing the nation and the world, such as responding to climate change and balanced use of coastal and marine resources. Through collaborations with subject matter experts, innovative and relevant science continues to be presented on SOS in a variety of formats and forums. By February 8, 2011, GSD will develop a strategic plan for SOS with the goal of improving society's environmental literacy and to provide the ability to make better informed environmental decisions.

   For Virtual Worlds, a paper was prepared by OAR titled "Recommendations for NOAA Strategic Engagement" that demonstrates the utility of this technology and provides a recommended strategy for implementation. This paper is available at http://www.scribd.com/doc/34071454/Virtual-Worlds-and-Immersive-Internet-White-Paper. Specific steps to advance this new technology within NOAA are being evaluated.

7. Together with the NOAA Office of Education and the Institute for Learning and Innovation, the SOS users collaborative network is currently involved in a program-wide evaluation of the effectiveness of the exhibits of spherical display systems. In addition, all SOS installations that have been funded through the NOAA Environmental Literacy Grants must conduct formal evaluation of their SOS exhibits. Evaluation reports are available online at http://www.oesd.noaa.gov/network/SOS_evals/index.html.

   Since its inception, the Virtual Worlds program has carefully monitored visitor levels and interactions. This report is available at http://www.slideshare.net/hackshaven/noaa-in-second-life-traffic-report-year-2009-in-review. Several universities and other government agencies have evaluated the effectives of Virtual Worlds in their programs. By October 31, 2010, we will create a proposal for the NOAA Office of Education to evaluate the educational value of Virtual Worlds.

Actions and due dates:

1. Review current evaluation practices of AWIPS-II and other possible methodologies for doing technology transfer evaluations and write a proposal to NWS for rapid prototyping work by December 31, 2010. Investigate any opportunities to collaborate with IMAPP by February 8, 2011.
2. Establish a matrix of generalized quality, performance, and maintainability metrics in collaboration with stakeholders by February 8, 2011.
3. Obtain and review the FAA REDAC report by February 8, 2011 to determine elements with potential to improve transition of ESRL research to operations.
4. Organize a Task Team to explore the feasibility of engaging an economist or other experts (out-sourced) to assist with developing cost-benefit analyses of technologies transferred by February 8, 2011.
5. Examine multiple ways to disseminate forecasts in the new connected world in partnership with NWS and other stakeholders by January 31, 2011.
6. By February 8, 2011, ESRL will develop a strategic plan for SOS.
7. By December 31, 2010, we will create a proposal for the NOAA Office of Education to evaluate the educational value of Virtual Worlds.

3.5a Weather Systems Observations and Analysis

Verbatim Review Recommendations:

1. The OSE activities should include standard WMO-recommended practices and metrics used by the majority of the NWP centers around the globe. Cost as well as benefit for new observation systems should be included in the assessment. ESRL should consider addressing geographic areas identified by the NRC report as challenges for network design, namely urban areas, coastal region, and mountainous terrain.
2. Given the extent of observational activities within ESRL, together with in-house modeling capabilities, ESRL should build a stronger effort in observing system evaluation and optimization.
3. ESRL should position itself as a ground validation resource for satellite data.

Responses:

1. GSD's Observing System Experiments (OSE) -related verification has used specifications consistent with the WMO raob verification algorithms documented under http://www.wmo.int/pages/prog/gcos/documents/gruanmanuals/GDPFS/WMO_485_Vol_I.pdf. GSD has described its extension to WMO mandatory-level-only raob verification in the Moninger et al. 2010 paper (http://ruc.noaa.gov/pdf/TAMDAR-WF-journal-6Oct09.pdf). We will learn yet more about the WMO practices, but we consider GSD extensions to have been extremely valuable in gaining physical understanding about data assimilation issues.

   Cost issues for possible future observing systems are the responsibility of the NWS. Future ESRL OSE efforts could be more formally coupled with NWS cost-related decision-making if needed.

2. GSD will seek new funding opportunities to support observing system evaluation and optimization. We will also form a team charged with developing and implementing methods to quantify/estimate observational uncertainties for data assimilation and Observing System Simulation Experiments (OSSEs), for monitoring the quality of major remote and in-situ observing systems assimilated into operational and research models, and to assist in evaluating the impact on attaining NOAA performance objectives. GSD will continue to participate in the establishment and development of the NOAA OSSE program to identify long-term interests and contributions, and will develop an OSSE strategic plan outlining long-term goals for implementing a comprehensive global OSSE system. This plan will study new observing systems and provide data supporting cost-benefit analyses.

3. GSD scientists have been contributing to ground validation of various satellite data and products in collaboration with the National Environmental Satellite, Data, and Information Service (NESDIS) and the Joint Center for Satellite Data Assimilation (JCSDA). We agree with the review panel that given GSD's expertise in ground-based GPS and other observing systems, there are further opportunities to be pursued.

Actions and due dates:

1. Based on the referenced paper by Moninger et al., GSD will prepare a report on the use of extensions to WMO standards for raob verification by February 8, 2011.
2. By February 8, 2011, GSD will form a team charged with developing and implementing methods to quantify/estimate observational uncertainties for data assimilation and OSSEs, for monitoring the quality of major remote and in-situ observing systems assimilated into operational and research models, and to assist in evaluating the impact on attaining NOAA performance objectives.
3. GSD will pursue broadening involvement with GOES-R, GPM, and other satellite system design and validation work via continued collaboration with NESDIS and JCSDA. Related research proposals will be prepared and submitted by February 8, 2011.

3.5b Climate Systems Observations and Analysis

Verbatim Review Recommendations:

1. ESRL should identify the NOAA and national context for sustaining their climate observing competency and excellence and thus the core expertise ESRL needs to maintain. A plan should then be developed to do so.
2. ESRL should consider hosting summer schools to sustain the core competency in key climate observing areas.

Responses:

1. PSD routinely develops and deploys state-of-the-art ground-based, air- and ship-borne observing systems. These systems provide data needed to better understand key air-sea, Arctic and water cycle processes, which in turn leads to a more complete understanding and more refined modeling of the Earth's climate system. The expertise PSD maintains in these sub-disciplines is unique in the world and is an important component of broader local, regional, national, and international efforts to improve our understanding of climate and water processes and their representation in forecast and prediction models. All PSD efforts are guided by NOAA's Next Generation Strategic Plan, Strengthening NOAA Science document, NOAA's Arctic Vision and Strategy, and the NOAA HMT Implementation Plan (Section 3.3.3). National and international guiding documents include Observing Weather and Climate from the Ground Up (National Research Council), Integrating Multi-scale Observations of U.S. Waters (National Academies Press), Observations To Quantify Air-Sea Fluxes and Their Role In Climate Variability and Predictability (summary white paper – International OceanObs09 Conference), and planning documents associated with the Study for Environmental Arctic Change (SEARCH).
2. PSD, through CIRES, has agreed to host the 16th International Symposium for the Advancement of Boundary Layer Remote Sensing in 2012. We will be exploring the opportunity for short courses, especially those that might include hands-on experiences at the Boulder Atmospheric Observatory 300-m tower site.

Actions and due dates:

1. By 03/31/2011- PSD will: (1) document the key observing system gaps related to PSD's science objectives (e.g., boundary layer processes, precipitation processes, air-sea fluxes), (2) assess opportunities to i) expand current capabilities to address unmet observation needs, ii) identify mutually beneficial strategic partnerships with other organizations, and iii) reduce current capabilities to eliminate low-impact technologies, (3) identify an ideal long-term (10-year) observing system profile that addresses key science needs and leverages existing and partner capabilities, (4) inventory the resources needed to sustain the current observing competency, and (5) develop and implement a long-term plan to adjust the current resource (people, funding, equipment) profile to accommodate long–term observational targets.
2. By 03/31/2010 - PSD will identify and explore other options for sustaining its observing system expertise through (1) targeted relationships with other institutions (academic, federal, commercial) which might be the source of required talent, (2) student internship programs to expose students to observing system science as a possible course of study and career path, and (3) planning for and engagement in observationally focused conferences.

Table 1
Summary of Actions

Report/Response Section	Action	Milestone	Status
2.1	Discuss the feasibility and methods of obtaining a better balance between base and external funding with OAR management.	12/15/2010	
2.3	1. Review postdoctoral staff assignments for each individual and make any needed tasking adjustments.	11/09/2010	
2.3	2. Implement mentoring through IDPs or equivalent mechanisms for junior staff.	02/08/2011	
2.3	2. Review annual appraisal and promotion processes for all employees with ESRL, CI, and contractor management to ensure that the goals of rewarding and retaining high quality personnel are being met.	02/08/2011	
2.3	3. Emphasize intranet publications and contents to all personnel and update new hire checklists to remind managers to inform new personnel of the weekly intranet publications.	10/08/2010	
2.3	3. Revise intranet publications to promote increased readership.	02/08/2011	
2.3	3. Senior staff, mentors, technical leads, and project leads will be requested to provide monthly notices and reminders to postdoctoral and graduate student staff about participation in seminars offered.	10/01/2010	
2.3	3. ESRL management will coordinate with postdoctoral and graduate student staff to determine the frequency of informal seminars, and work through the ESRL Student Coordinator to provide more organized social events for the postdoctoral and graduate student staff.	10/05/2010	
2.3	3. ESRL management will highlight the availability of gathering areas throughout the building and approach the NOAA Boulder Directors Council to determine the feasibility of enhancements to building gathering areas.	12/07/2010	
2.3	4. ESRL managers will be directed to take an active role determining the aspirations of their personnel, making use of IDPs and providing training, mentoring, and development	10/05/2010	

	opportunities.		
3.1	1. PSD will explore how best to advance its model diagnostics capability, perhaps in concert with the recently proposed Environmental Projection Center within the NCS.	03/31/2011	
3.1	2. Within 90 days of the formation of a NOAA Climate Service, PSD→PSL will discuss possible configurations for an enhanced and better-integrated Arctic program with NCS management..	03/31/2011	
3.1	3. Within 90 days of the formation of a NOAA Climate Service, PSD→PSL will discuss possible avenues for elevating NOAA's leadership role in facilitating some broader international coordination for Arctic observations with NCS management.	03/31/2011	
3.1	4. PSD will: (1) create a demographic profile of the personnel within the climate observations group, (2) develop projections of near-term and longer-term transitions by, (3) develop a list of personnel options (e.g., holding on to talented postdoctoral personnel, converting a few of our gifted CI people to federal, or recruiting new Feds from University/Research Laboratories), and (4) develop and implement a long-term plan to transition key positions using the options identified above.	03/31/2011	
3.2	3. Establish monthly reports published on the web to provide the skill from different versions of FIM vs. GFS.	10/05/2010	
3.2	5. Produce the first draft of the GSD 5-10 year strategic plan.	10/05/2010	
3.2	5. Initiate a coordination meeting on inline chemistry modeling and data assimilation with NWS and OAR colleagues and seek collaborative funding.	02/08/2011	
3.2	6. Explore working more with the NESSI group.	02/08/2011	
3.3	1. If an NCS is created, PSD→PSL will work to codify its methods for implementing NCS metrics for transition of products to services.	03/31/2011	
3.3	2. Within 90 days of the formation of a NOAA Climate Services that will also result in a final determination of CPC being either within or outside of the NCS line office, PSD→PSL will	03/31/2011	

	work with NCS management to develop either internal agreements or cross line office MOAs to establish mechanisms to ensure the development and delivery of monitoring and prediction services across temporal and spatial scales that will be transparent to users.		
3.4	1. Review current evaluation practices of AWIPS-II and other possible methodologies for doing technology transfer evaluations and write a proposal to NWS for rapid prototyping work.	12/31/2010	
3.4	1. Investigate any opportunities to collaborate with IMAPP.	02/08/2011	
3.4	2. Establish a matrix of generalized quality, performance, and maintainability metrics.	02/08/2011	
3.4	3. Obtain and review the FAA REDAC report to determine elements with potential to improve transition of ESRL research to operations.	02/08/2011	
3.4	4. Organize a Task Team to explore the feasibility of engaging an economist or other experts (out-sourced) to assist with developing cost-benefit analyses of technologies transferred.	02/08/2011	
3.4	5. Examine multiple ways to disseminate forecasts in the new connected world in partnership with NWS and other stakeholders.	1/31/2011	
3.4	6. Develop a strategic plan for SOS.	02/08/2011	
3.4	7. Create a proposal for the Office of Education to evaluate the educational value of Virtual Worlds.	12/31/2010	
3.5a	1. GSD will prepare a report on the use of extensions to WMO standards for raob verification.	02/08/2011	
3.5a	2. Form a team for developing and implementing methods to quantify/estimate observational uncertainties for data assimilation and OSSEs, monitoring the quality of major remote and in-situ observing systems assimilated into operational and research models, and to assist in evaluating the impact on attaining NOAA performance objectives	02/08/2011	
3.5a	3. Prepare and submit satellite design and validation work proposals.	02/08/2011	
3.5b	1. PSD will: (1) document the key observing system gaps related to PSD's science objectives (e.g., boundary layer processes, precipitation processes, air-sea fluxes), (2) assess	03/31/2011	

	opportunities to i) expand current capabilities to address unmet observation needs, ii) identify mutually beneficial strategic partnerships with other organizations, and iii) reduce current capabilities to eliminate low-impact technologies, (3) identify an ideal long-term (10-year) observing system profile that addresses key science needs and leverages existing and partner capabilities, (4) inventory the resources needed to sustain the current observing competency, and (5) develop and implement a long-term plan to adjust the current resource (people, funding, equipment) profile to accommodate long–term observational targets.		
3.5b	2. PSD will look into the possibility of hosting summer schools or similar events to maintain and build key observing system competencies, and will plan and implement an event in the summer of 2011.	03/31/2011	
3.5b	3. PSD will identify and explore other options for sustaining its observing system expertise through (1) targeted relationships with other institutions (academic, federal, commercial) which might be the source of required talent, (2) student internship programs to expose students to observing system science as a possible course of study and career path, and (3) planning for and engagement in observationally focused conferences.	03/31/2011	